TABLES AND DIAGRAMS

FOR OBTAINING THE

Resisting Moments of Eccentric Riveted Connections

BY

E. A. REXFORD

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RESISTING MOMENTS OF ECCENTRIC RIVETED CONNECTIONS

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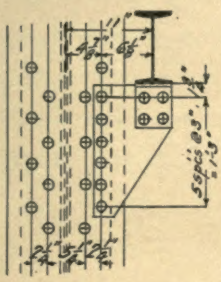
HOW TO APPLY THE TABLES

The purpose of these tables is to facilitate the operations of obtaining the resisting moments of eccentric riveted connections, and is intended especially for use in designing connections to columns where eccentric loads are involved.

The following problem illustrates the application of the table:

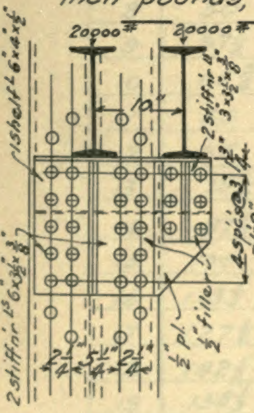


Suppose we have a beam framing to a column 11" off the center line of the column and that the reaction of the beam is 12000.#

Use a single row of rivets to connect the bracket to the column and the pitch of the rivets will be 3".

The load is $6\frac{1}{8}$" from the center line of the rivets and the bending moment is therefore $6\frac{1}{8} \times 12000 = 73500$ inch lbs.

Assume that six rivets are required.- Turning to page 1 we find that for a single row of six rivets with a 3" pitch the coefficient is 21. The stress per rivet due to direct load is 12000# ÷ 6 = 2000.# Referring to the sketch, page 1, and laying off the stress per rivet due to direct load on the vertical ordinate at the left and then moving parallel to the abscissae until reaching the 4420# curve, since the rivets are in single shear, thence vertically downward to the base line we find that the allowable bending stress on the extreme rivet is 3900.# Multiplying $21 \times 3900 = 81900$ inch pounds = the resisting moment of the connection. The bending moment is 73500 inch pounds, and therefore the connection is safe. $\frac{3}{4}$" rivets were used.



Load = 40,000#
Rivets $\frac{3}{4}$" dia.
Assume 20 rivets.
Stress per rivet due to direct load = 2000.#
Bending stress on extreme rivet = 2900.#
C = 86.2
Resisting Moment =
$86.2 \times 2900 = 249{,}980$ in lbs.
Bending Moment =
$10 \times 20{,}000 = 200{,}000$ in. lbs.
∴ The connection is safe.

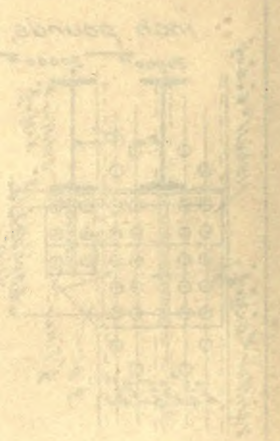
It may be noticed that the two $6" \times 3\frac{1}{2}" \times \frac{3}{8}"$ stiffener Ls. under the beam on the column center extend the full length of the connection plate, and embrace all the rivets in the connection. This is done to distribute the shear due to direct load uniformly among all the rivets. In this particular case, where the resisting moment so greatly exceeds the bending moment, the four bottom rivets could be omitted from the stiffeners and the connection still be safe.

HOW TO APPLY THE TABLES

The purpose of these tables is to facilitate the operations of obtaining the resisting moments of eccentric riveted connections, and is intended especially for use in designing connections to columns where eccentric loads are involved.

The following problem illustrates the application of the table:

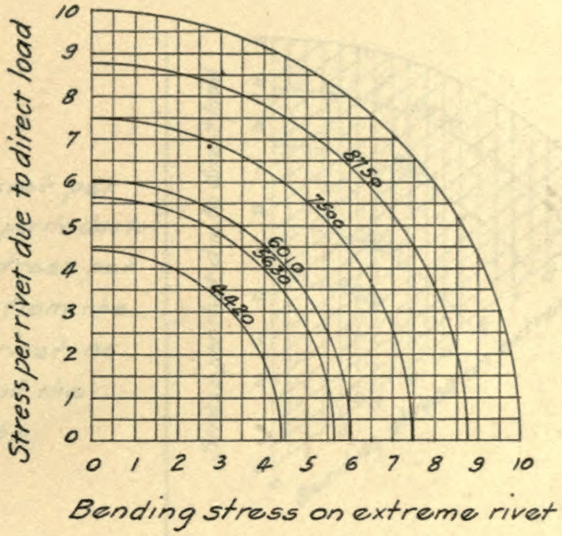
Suppose we have a beam framing to a column 6" from center line of the column and that the reaction of the beam is 12000#. Use a single row of rivets to connect the bracket to the column and the pitch of the rivets will be 3". The load is 6¼" from the center line of the rivets and the bending moment is therefore 6¼ × 12000 = 75000 inch lbs. Assume that six rivets are required. Turning to page 1 we find that for a single row of six rivets with a 3" pitch the coefficient is 21. The stress per rivet due to direct load is 12000÷6 = 2000#. Referring to the chart, page [illegible], and [illegible] the stress per rivet due to direct load on the vertical ordinate at the left and then moving parallel to the abscissa until reaching the 4420# curve, since the rivets are in single shear, thence vertically downward to the base line we find that the allowable bending stress on the extreme rivet is 3900#. Multiplying 21 × 3900 = 81900 inch pounds = the resisting moment of the connection. The bending moment is 75000 inch pounds and therefore the connection is safe. ¾" rivets were used.



Load = 6000#
Rivets ⅞" dia
Assume 20 rivets
Stress per rivet due to direct load = 300#
Bending stress on extreme rivets 2900#
C = 86.2
Resisting moment = 86.2 × 2900 = 249980 in lbs.
Bending Moment [illegible]
[illegible]
∴ The connection is safe.

It may be noticed that the two [illegible] stiffener angles on the beam connection are not riveted the full length of the connection plate and some of the rivets in the connection. This is done to distribute the shear due to direct load [illegible] rivets. In this particular case where the resisting moment is [illegible] bending moment, [illegible]

PLATE 1.



One Row of Rivets - Uniform Pitch

No. Rivs.	2½"	3"	3½"	4"	4½"	5"	6"
1	0	0	0	0	0	0	0
2	2½	3	3½	4	4½	5	6
3	5	6	7	8	9	10	12
4	8⅓	10	11⅔	13⅓	15	16⅔	20
5	12½	15	17½	20	22½	25	30
6	17½	21	24½	28	31½	35	42
7	23⅓	28	32⅔	37⅓	42	46⅔	56
8	30	36	42	48	54	60	72
9	37½	45	52½	60	67½	75	90
10	45⅚	55	64⅙	73⅓	82½	91⅔	110
11	55	66	77	88	99	110	132
12	65	78	91	104	117	130	156
13	75⅚	91	106⅙	121⅓	136½	151⅔	182
14	87½	105	122½	140	157½	175	210
15	100	120	140	160	180	200	240
16	113⅓	136	158⅔	181⅓	204	226⅔	272
17	127½	153	178½	204	229½	255	306
18	142½	171	199½	228	256½	285	342
19	158⅓	190	221⅔	253⅓	285	316⅔	380
20	175	210	245	280	315	350	420

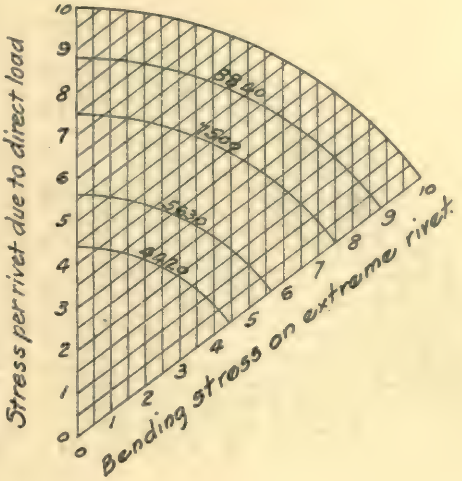
PLATE 2.

Two rows of rivets - $2\frac{1}{4}$" ctr. to ctr. of rows - Rivets spaced 3" ctr. to ctr. in the rows. Rivets not staggered.

Where there is one rivet per row to obtain the stress per riv. due to bending subtract the stress per rivet due to direct load from the resisting value of the rivet, or from the bearing value of the plate as the case may be.

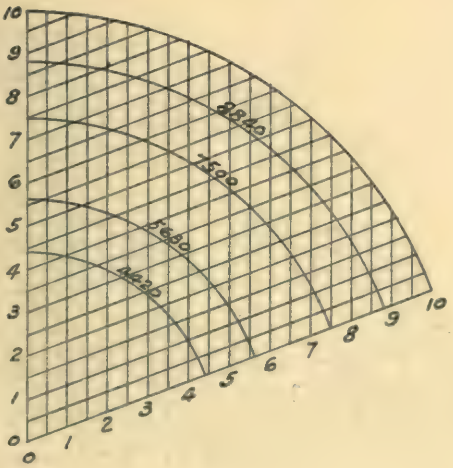
1 Rivet per row.

C = 2.25



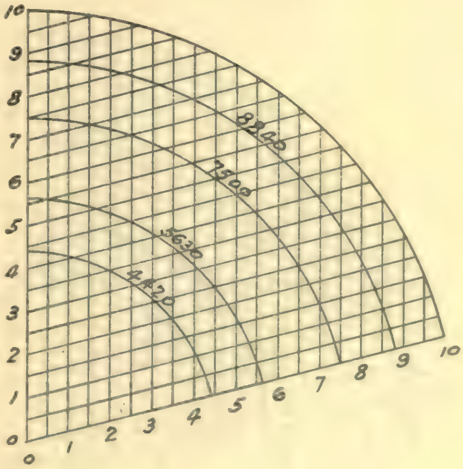
2 Rivets per row.

C = 7.50



3 Rivets per row.

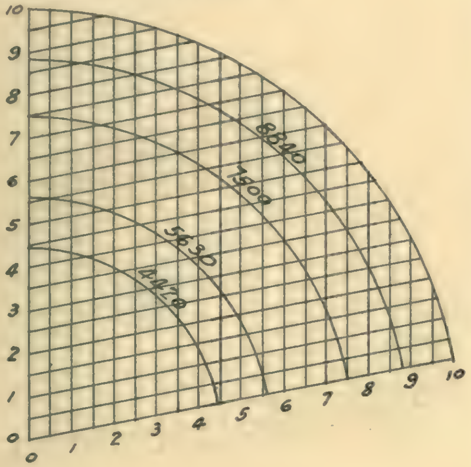
C = 13.60



4 Rivets per row.

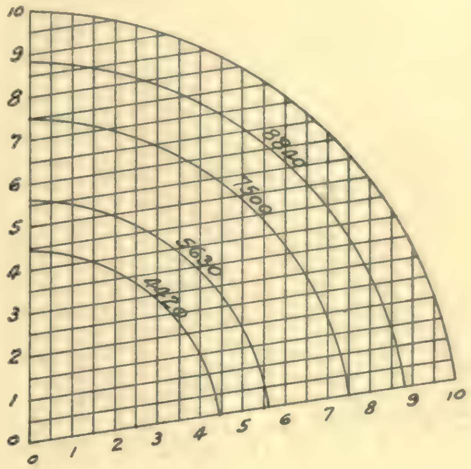
C = 21.60

Two rows of rivets.-$2\frac{1}{4}$" ctr. to ctr. of rows. Rivets spaced 3" ctr to ctr in the rows. Rivets not staggered.



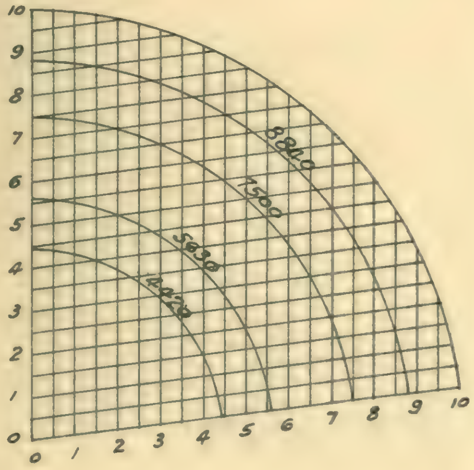
5 Rivets per row

C = 31.50



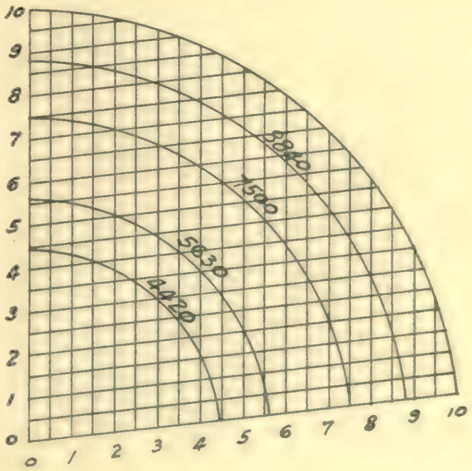
6 Rivets per row.

C = 43.50



7 Rivets per row

C = 57.50

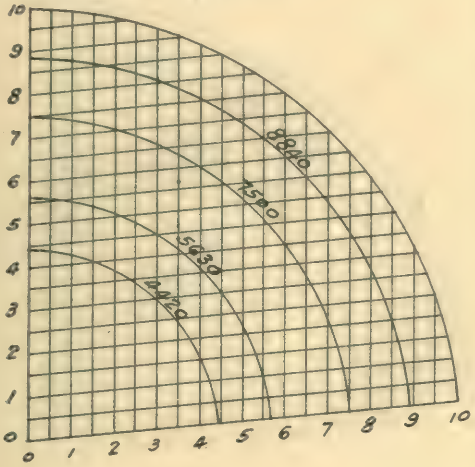


8 Rivets per row

C = 73.50

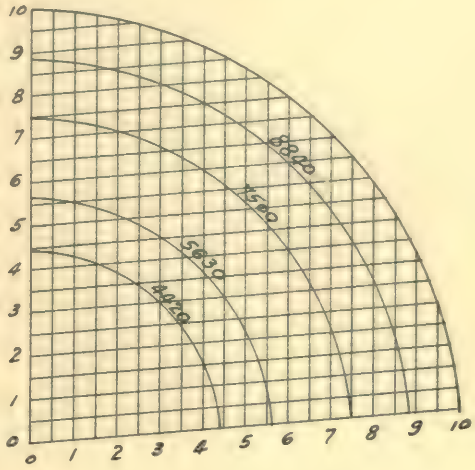
PLATE 4.

Two rows of rivets - $2\frac{1}{4}''$ ctr to ctr of rows.- Rivets spaced 3" ctr to ctr. in the rows.
Rivets not staggered



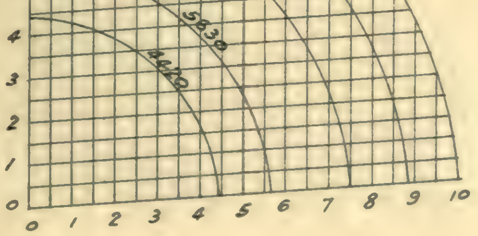
9 Rivets per row

C = 91.50



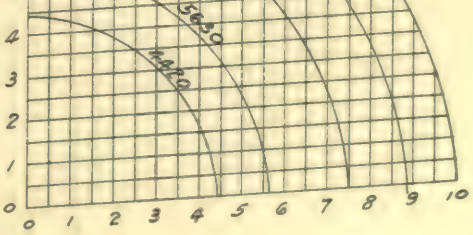
10 Rivets per row.

C = 111.50



11 Rivets per row

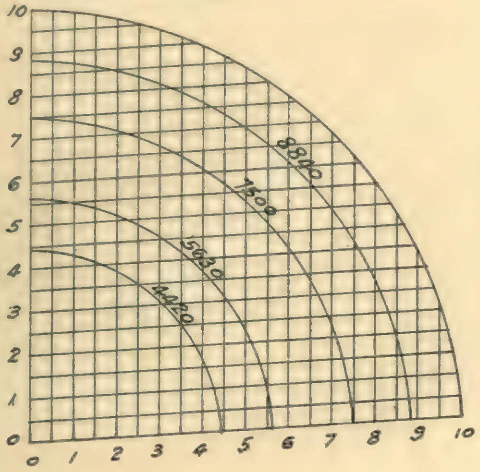
C = 133.50



12 Rivets per row

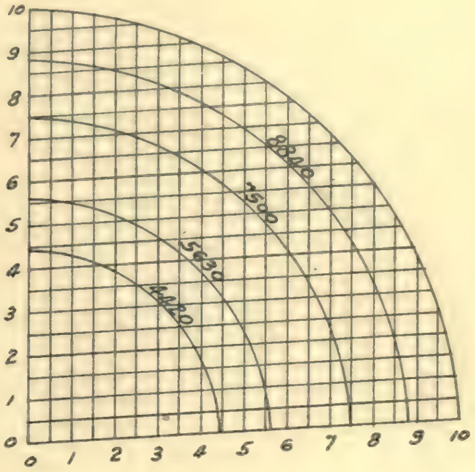
C = 157.50

Two rows of rivets - $2\frac{1}{4}$" ctr to ctr of rows - Rivets spaced 3" ctr to ctr. in the rows. Rivets not staggered.



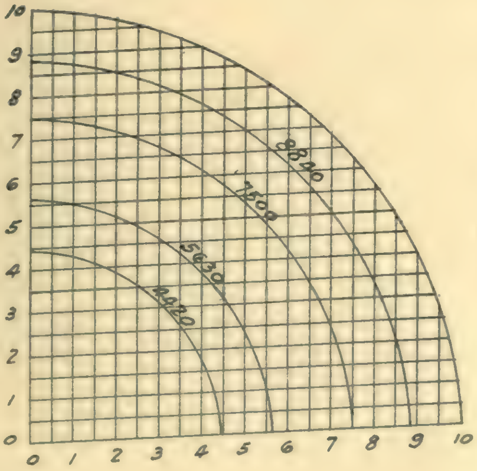
13 Rivets per row

C = 183.50



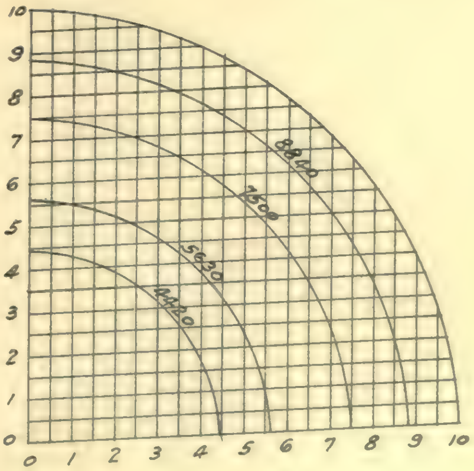
14 Rivets per row.

C = 211.50



15 Rivets per row

C = 241.50

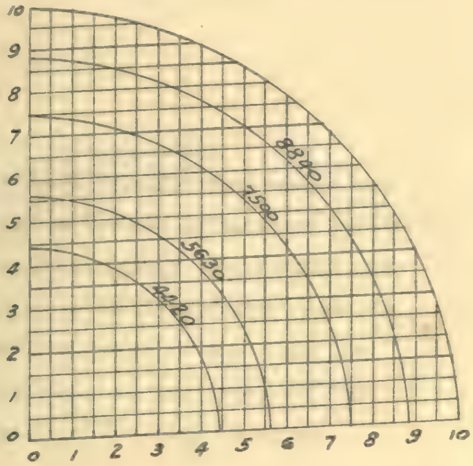


16 Rivets per row

C = 273.50

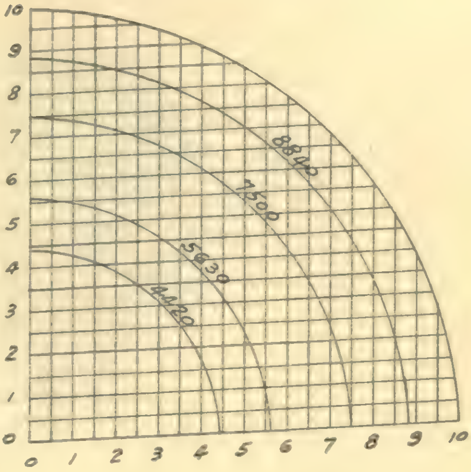
PLATE 6.

Two rows of rivets:- $2\frac{1}{4}''$ ctr. to ctr. of rows.- Rivets spaced 3" ctr. to ctr. in the rows. Rivets not staggered.



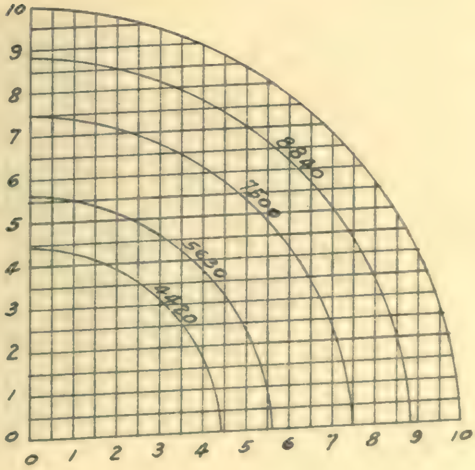
17 Rivets per row

C=307.50



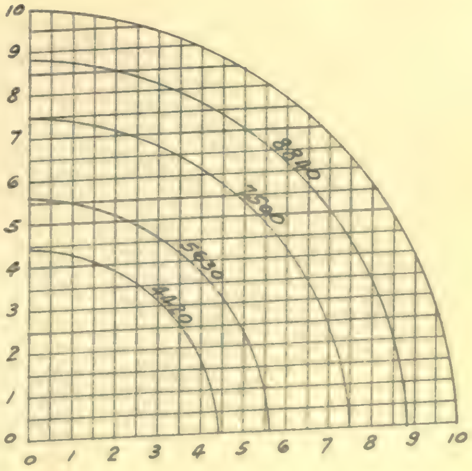
18 Rivets per row

C=343.50



19 Rivets per row

C=381.50



20 Rivets per row

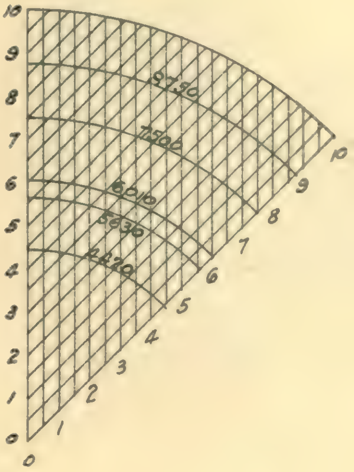
C=421.50

PLATE 7.

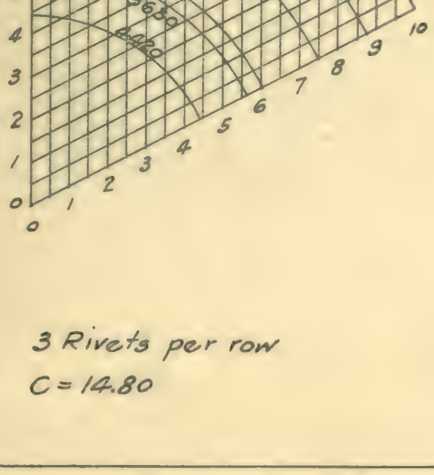
Two rows of rivets–3"ctr. to ctr. of rows. Rivets spaced 3"ctr. to ctr. in the rows. Rivets not staggered.

Where there is one rivet per row to obtain the stress per riv. due to bending subtract the stress per rivet due to direct load from the resisting value of the rivet, or from the bearing value of the plate as the case may be.

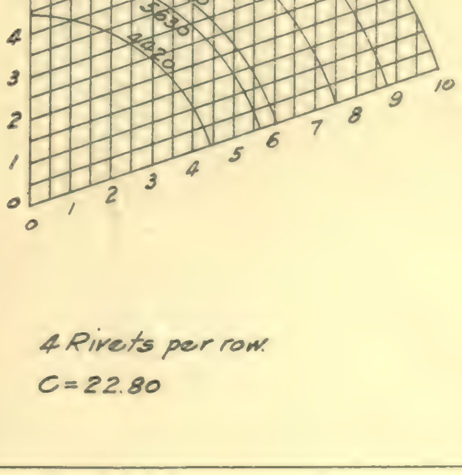
1 Rivet per row.
C=3



2 Rivets per row
C=8.50



3 Rivets per row
C=14.80

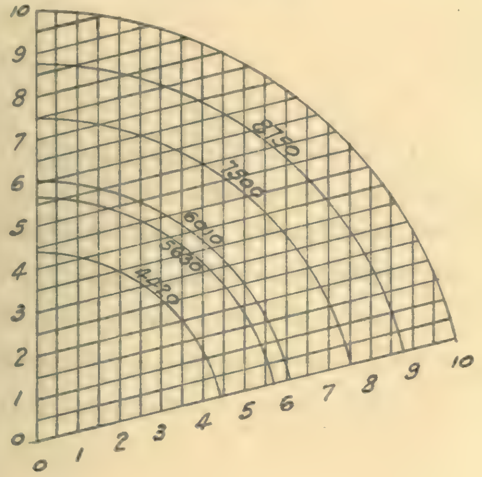


4 Rivets per row.
C=22.80

PLATE 8.

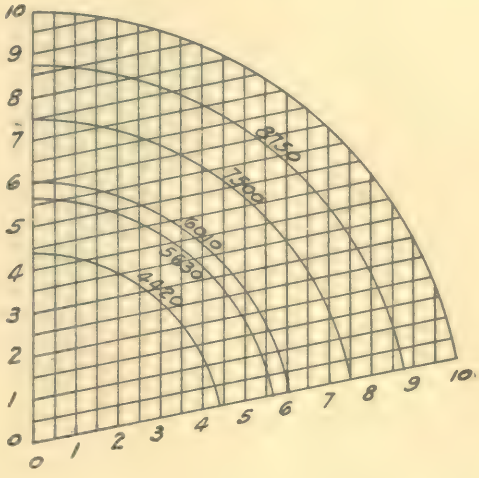
Two rows of rivets-3" ctr. to ctr. of rows. Rivets spaced 3" ctr. to ctr. in the rows.

Rivets not staggered.



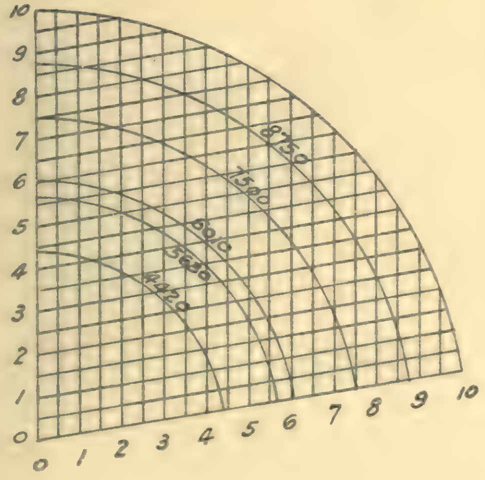
5 Rivets per row.

C=32.80



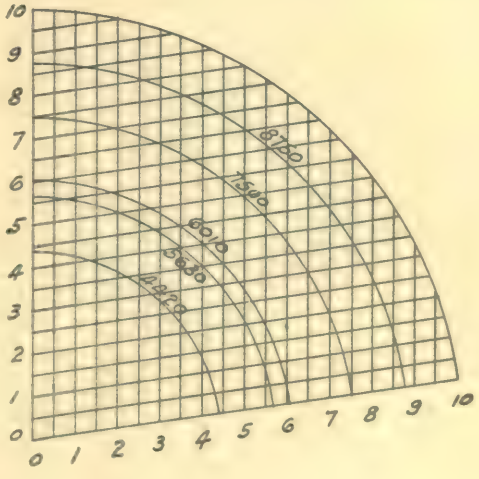
6 Rivets per row.

C=44.70



7 Rivets per row.

C=58.70



8 Rivets per row.

C=74.60

Note. Fos more than 8 rivets per row use values for two rows of rivets $2\frac{1}{4}$" c. to c. of rows pp. 4-5-6.

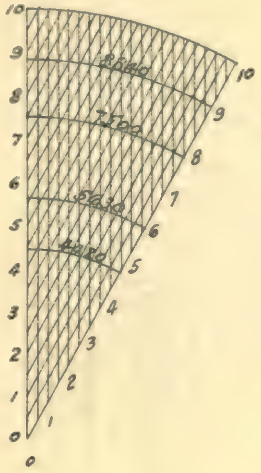
PLATE 9.

Two rows of rivets - $5\frac{1}{4}''$ ctr to ctr. of rows. - Rivets spaced 3" ctr to ctr. in the rows. Rivets not staggered

Where there is one rivet per row to obtain the stress per riv. due to bending subtract the stress per rivet due to direct load from the resisting value of the rivet, or from the bearing value of the plate as the case may be.

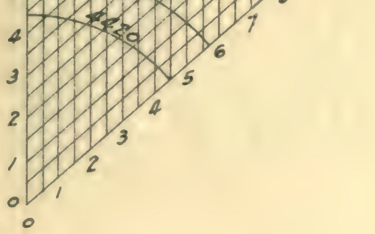
1 Rivet per row

C = 5.25



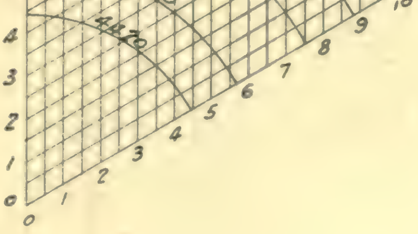
2 Rivets per row

C = 12.10



3 Rivets per row.

C = 19.40

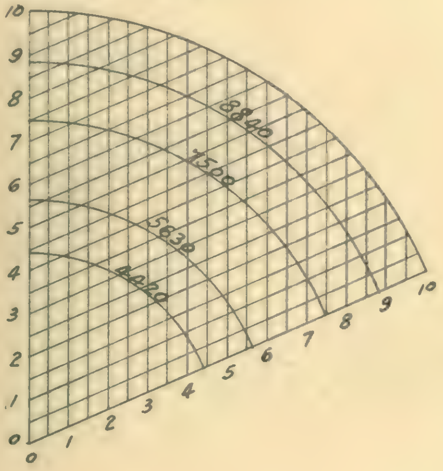


4 Rivets per row.

C = 27.80

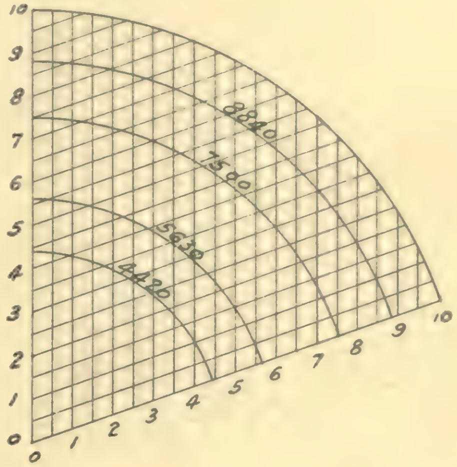
Two rows of rivets – $5\frac{1}{4}''$ ctr. to ctr. of rows – Rivets spaced $3''$ ctr. to ctr. in the rows

Rivets not staggered.



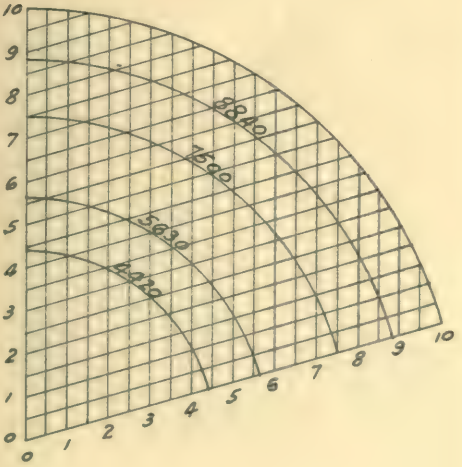
5 Rivets per row

C = 38



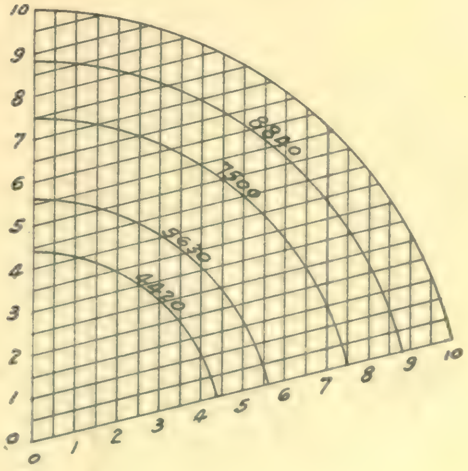
6 Rivets per row

C = 50.



7 Rivets per row

C = 64



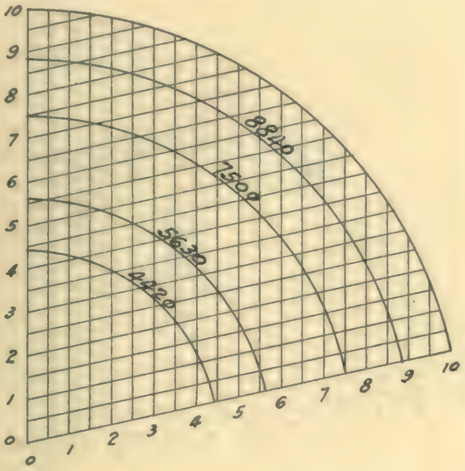
8 Rivets per row

C = 80.

PLATE 11

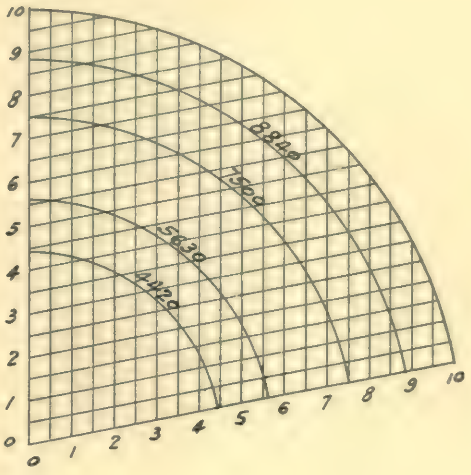
Two rows of rivets.- $5\frac{1}{4}''$ ctr. to ctr. of rows.- Rivets spaced 3" ctr. to ctr. in the rows.

Rivets not staggered



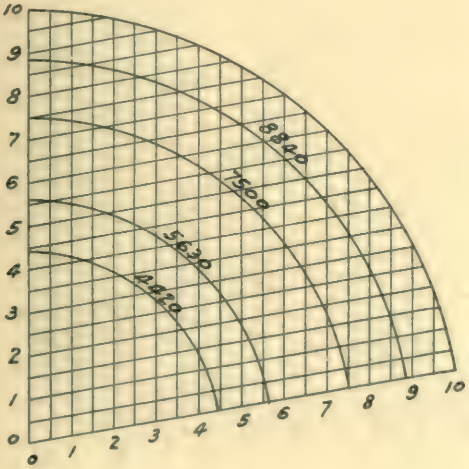
9 Rivets per row

C = 98



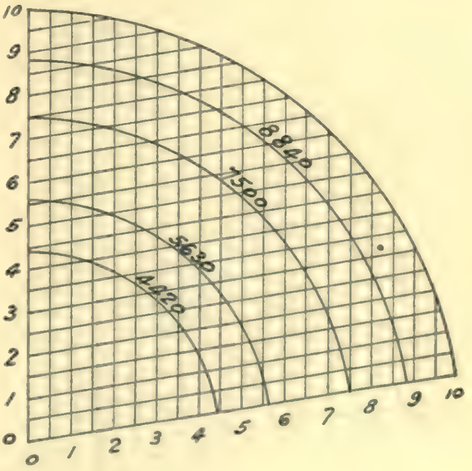
10 Rivets per row

C = 118



11 Rivets per row

C = 140



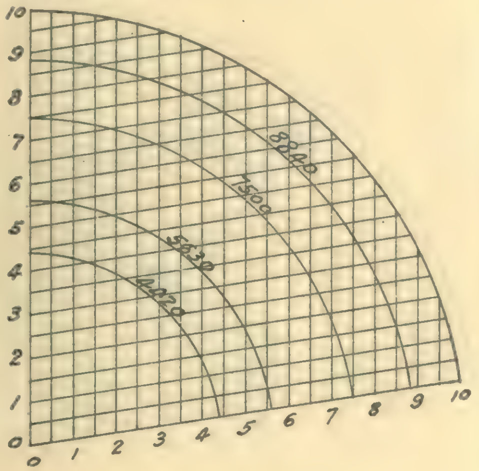
12 Rivets per row

C = 164.10

PLATE 12

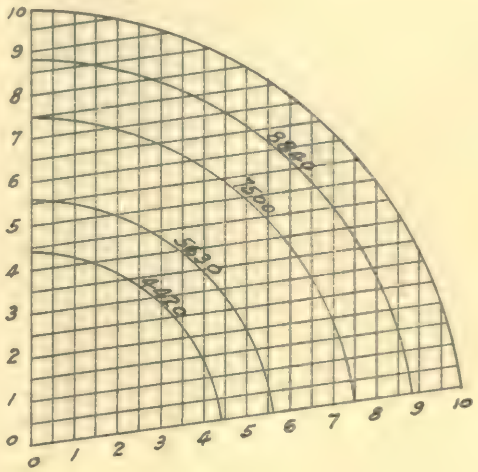
Two rows of rivets - 5¼" ctr. to ctr. of rows. - Rivets spaced 3" ctr. to ctr. in the rows.

Rivets not staggered



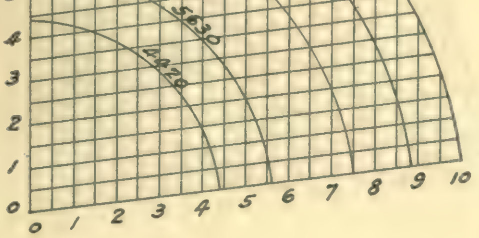
13 Rivets per row

C = 189.90



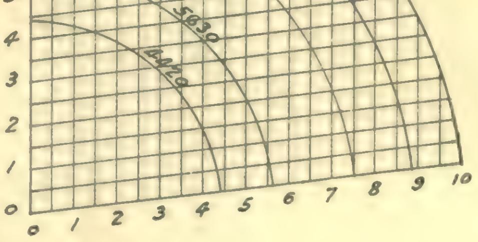
14 Rivets per row

C = 217.90



15 Rivets per row

C = 247.90

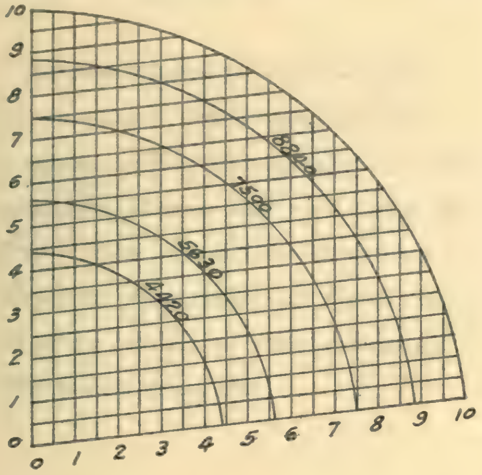


16 Rivets per row

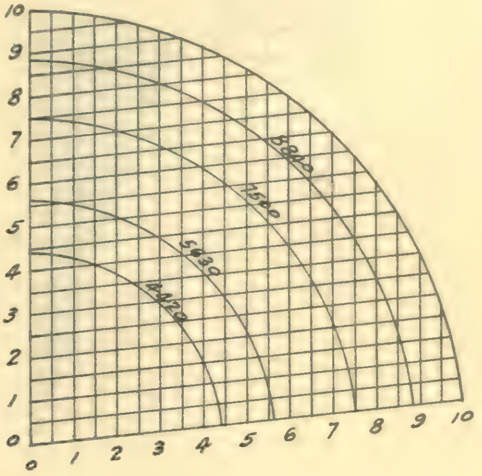
C = 279.90

PLATE 13

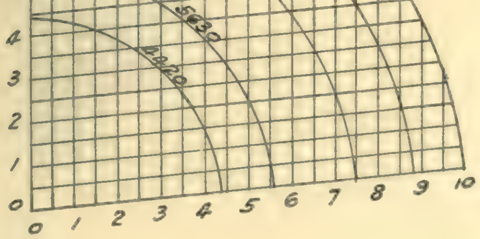
Two rows of rivets.- $5\frac{1}{4}$" ctr. to ctr. of rows.- Rivets spaced 3" ctr. to ctr. in the rows. Rivets not staggered.



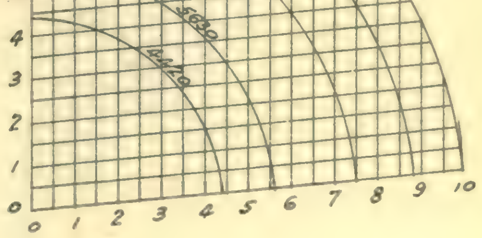
17 Rivets per row
C=313.90



18 Rivets per row
C=349.90

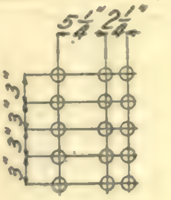


19 Rivets per row.
C=387.90



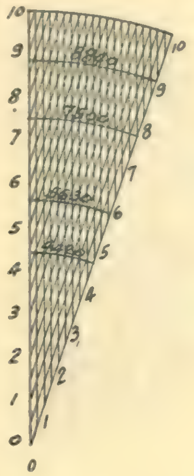
20 Rivets per row
C=427.90

Three rows of rivets-distances between rows as shown
Rivets spaced 3" ctr. to ctr. in the rows.

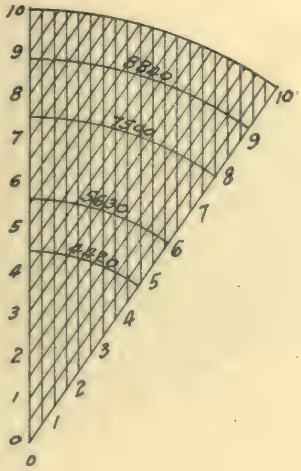


Where there is one rivet per row to obtain the stress due to bending on the extreme rivet subtract the stress per rivet due to direct load from the resisting value of the rivet, or from the bearing value of the plate as the case may be.

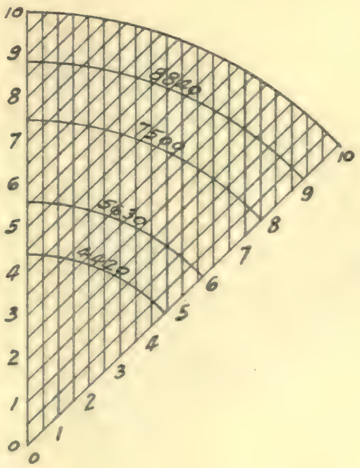
1 Rivet per row
C = 7



2 Rivets per row
C = 16.10

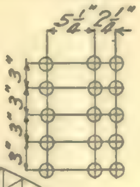


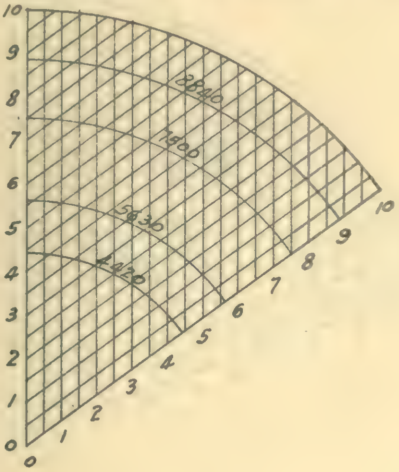
3 Rivets per row
C = 27.50



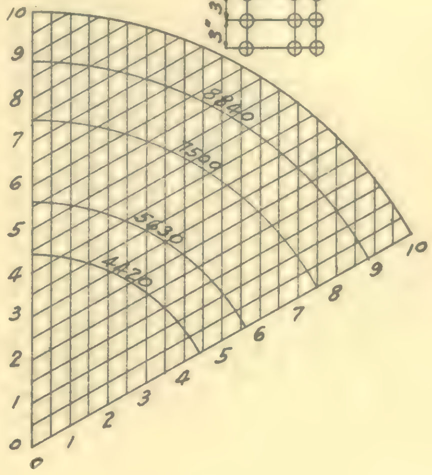
4 Rivets per row
C = 41

Three rows of rivets – distances between rows as shown
Rivets spaced 3" ctr. to ctr. in the rows.

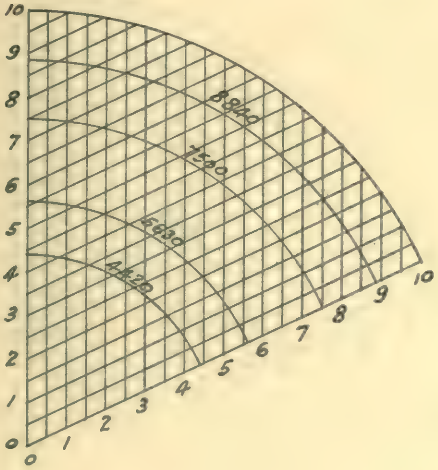




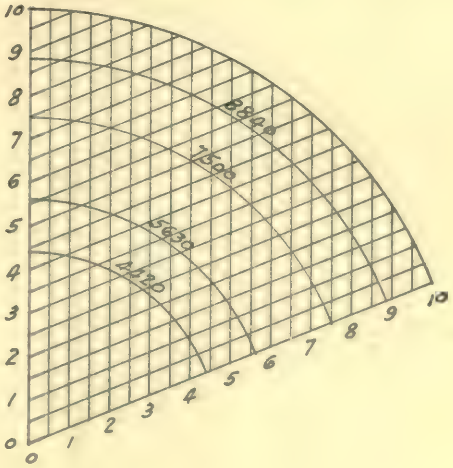
5 Rivets per row
C = 56.90



6 Rivets per row
C = 75.40

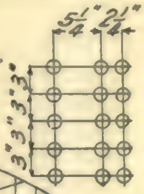


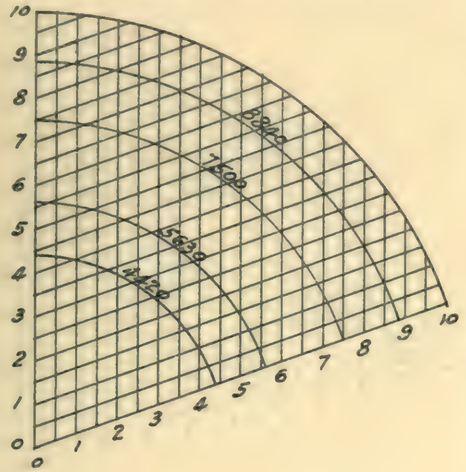
7 Rivets per row
C = 96.80



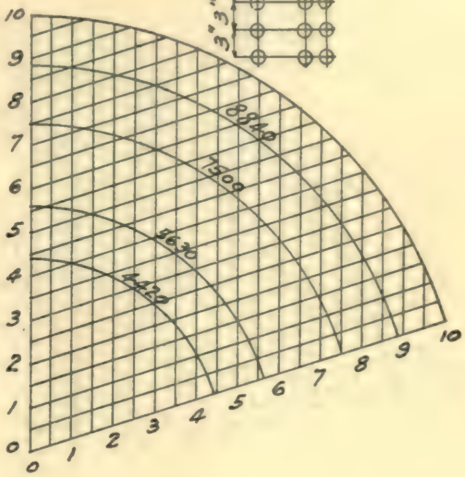
8 Rivets per row
C = 121

Three rows of rivets - distances between rows as shown.
Rivets spaced 3" ctr. to ctr. in the rows.

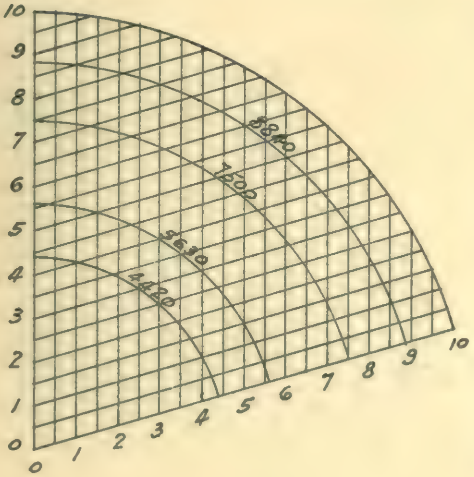




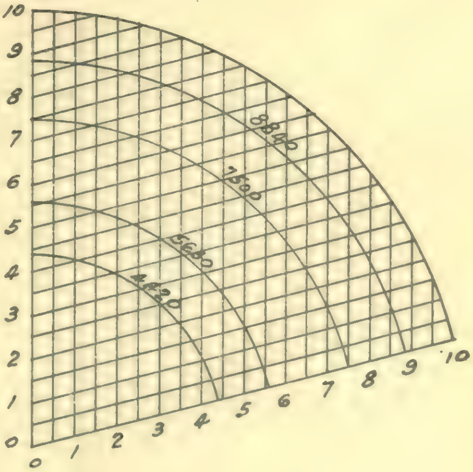
9 Rivets per row
C = 148.20



10 Rivets per row
C = 178.30



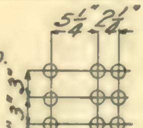
11 Rivets per row
C = 211.40



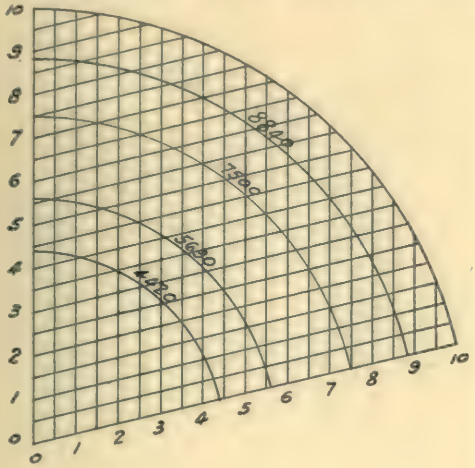
12 Rivets per row
C = 247.50

PLATE 17

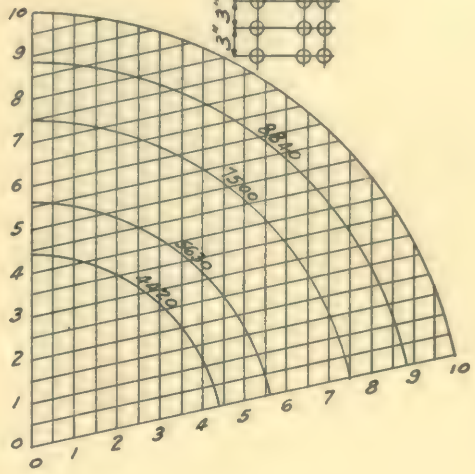
Three rows of rivets - distances between rows as shown.
Rivets spaced 3" ctr. to ctr. in the rows.



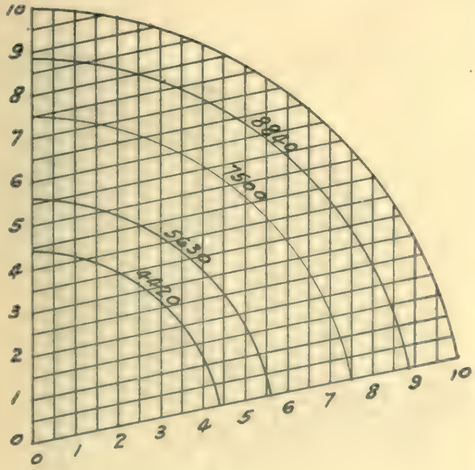
$5\frac{1}{4}$"
$2\frac{1}{4}$"
3"
3"
3"
3"



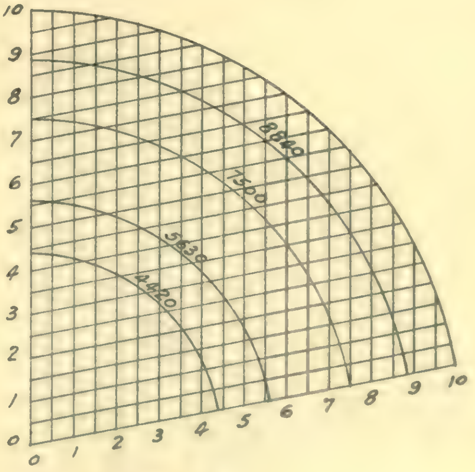
13 Rivets per row
C=286.50



14 Rivets per row
C=328.50



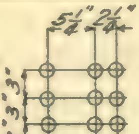
15 Rivets per row
C=373.60

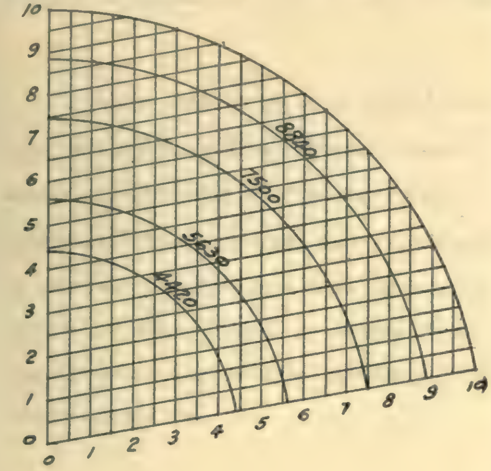


16 Rivets per row
C=421.60

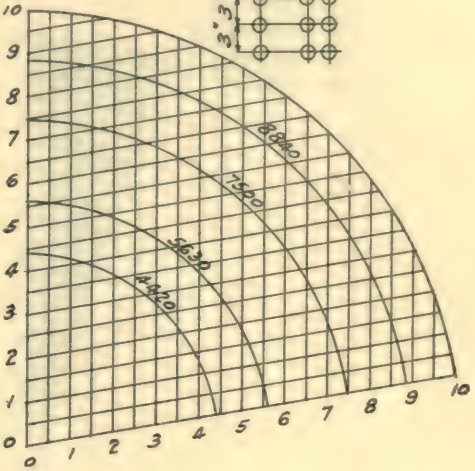
PL. 18

Three rows of rivets- distances between rows as shown.
Rivets spaced 3" ctr. to ctr. in the rows.

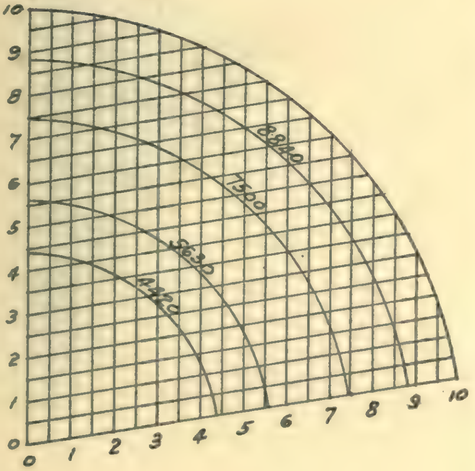




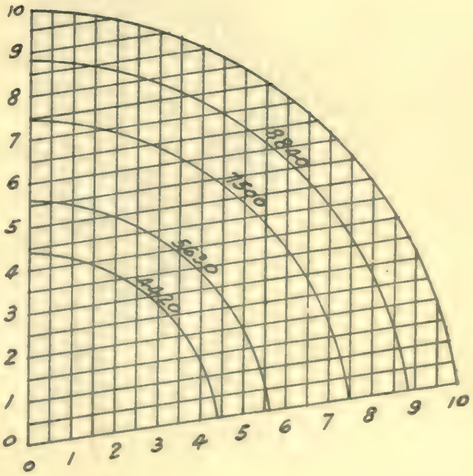
17 Rivets per row
C=472.60



18 Rivets per row
C=526.60



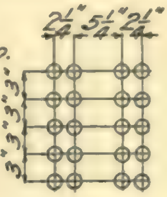
19 Rivets per row
C=583.70



20 Rivets per row
C=643.70

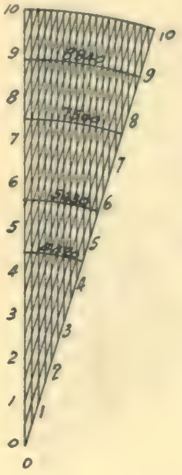
PL. 19

Four rows of rivets-distances between rows as shown.
Rivets spaced 3" ctr. to ctr. in the rows.

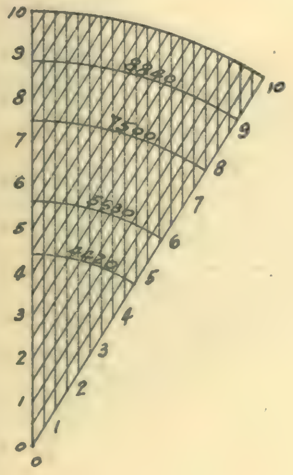


Where there is one rivet per row to obtain the stress due to bending on the extreme rivet subtract the stress per rivet due to direct load from the resisting value of the rivet, or from the bearing value of the plate as the case may be.

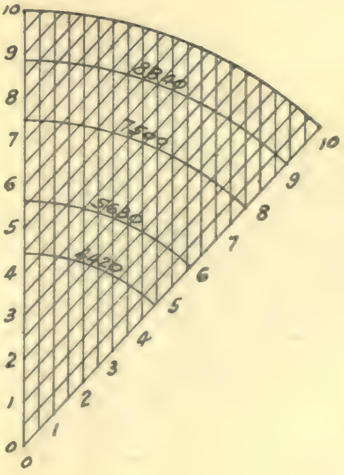
1 Rivet per row
C=12.60



2 Rivets per row
C=27.60

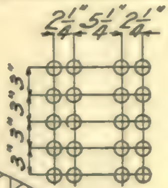


3 Rivets per row
C=44.70

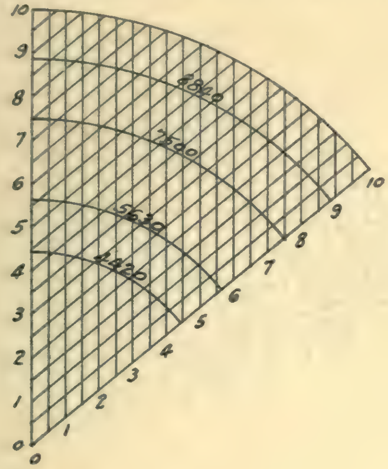


4 Rivets per row
C=64.10

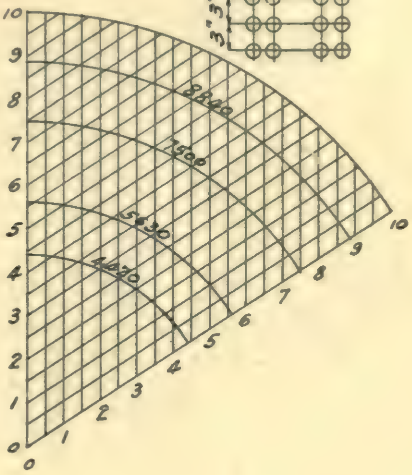
Four rows of rivets - distances between rows as shown
Rivets spaced 3" ctr. to ctr. in the rows.


$2\frac{1}{4}$"
$5\frac{1}{4}$"
$2\frac{1}{4}$"
3"
3"
3"
3"

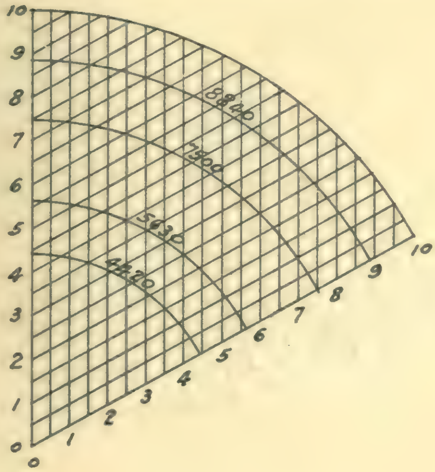
PL. 20



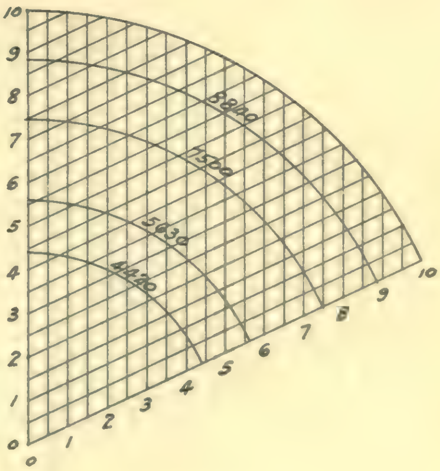
5 Rivets per row
C=86.20



6 Rivets per row
C=111.50



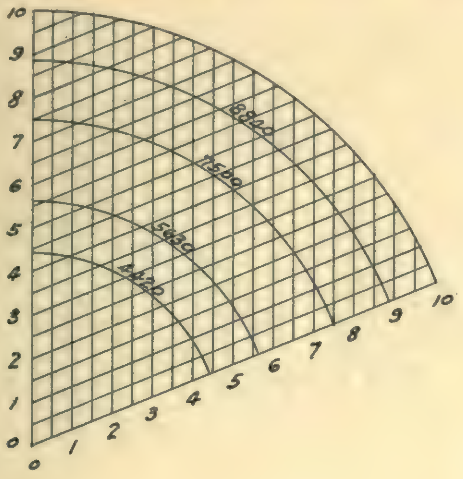
7 Rivets per row
C=140.40



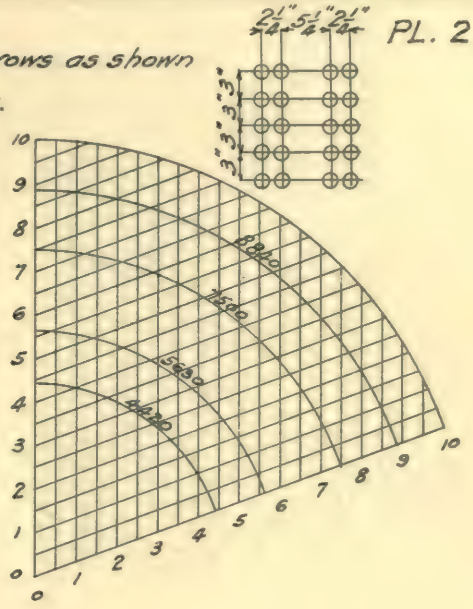
8 Rivets per row
C=173

PL. 21

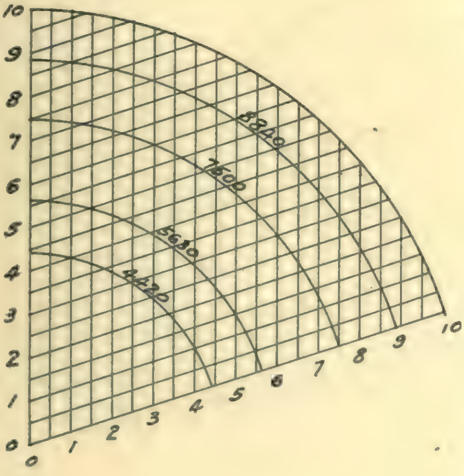
Four rows of rivets–distances between rows as shown
Rivets spaced 3" ctr. to ctr. in the rows.



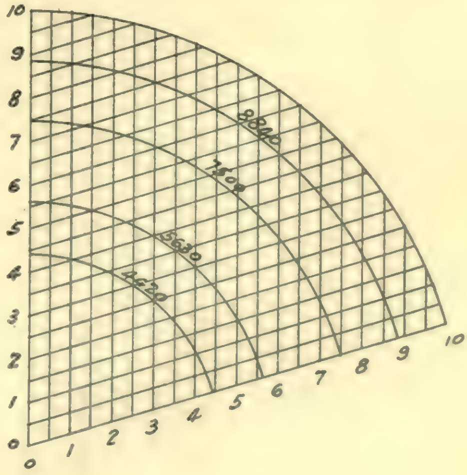
9 Rivets per row
C=209.40



10 Rivets per row
C=249.60

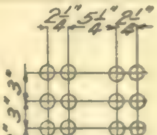


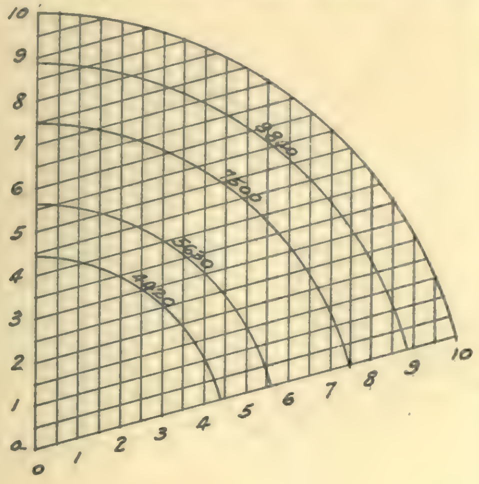
11 Rivets per row
C=293.80



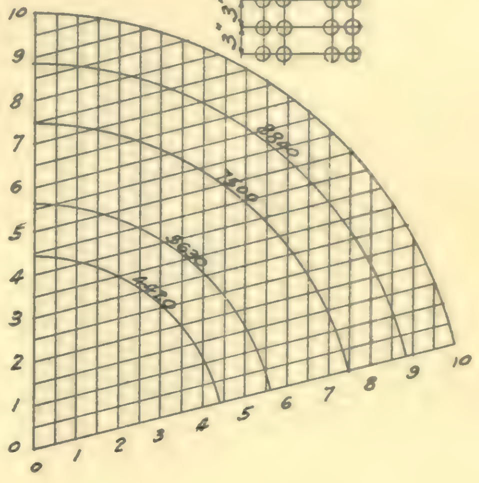
12 Rivets per row.
C=342

Four rows of rivets - distances between rows as shown
Rivets spaced 3" ctr. to ctr. in the rows.

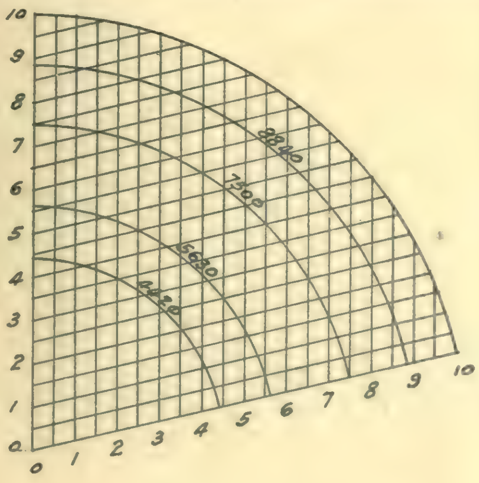




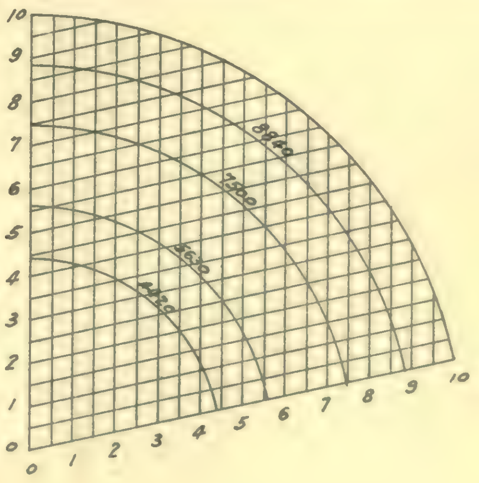
13 Rivets per row
C=394.10



14 Rivets per row
C=450.20

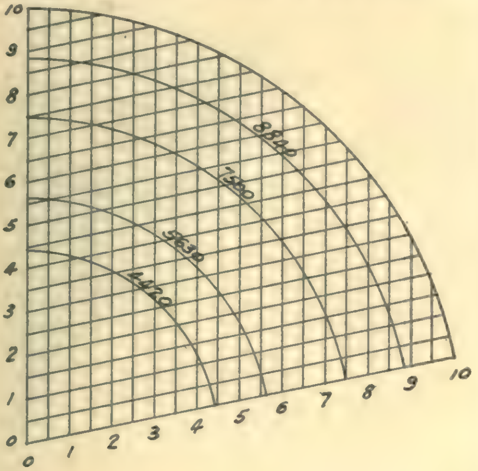


15 Rivets per row
C=510.20

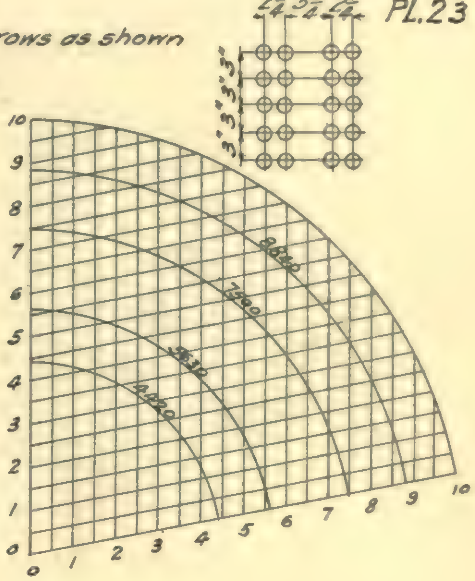


16 Rivets per row
C=574.30

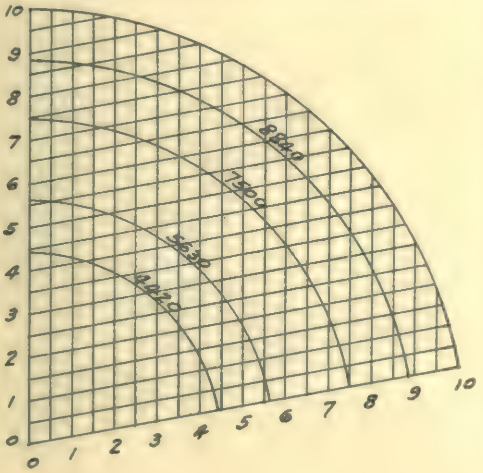
Four rows of rivets- distances between rows as shown
Rivets spaced 3" ctr. to ctr. in the rows.



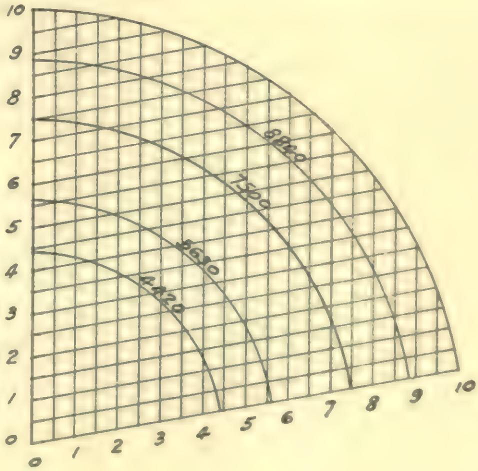
17 Rivets per row
C=642.30



18 Rivets per row.
C=714.30



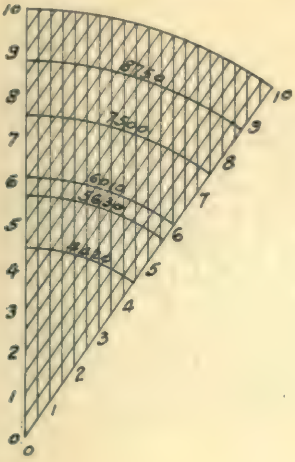
19 Rivets per row
C=790.40



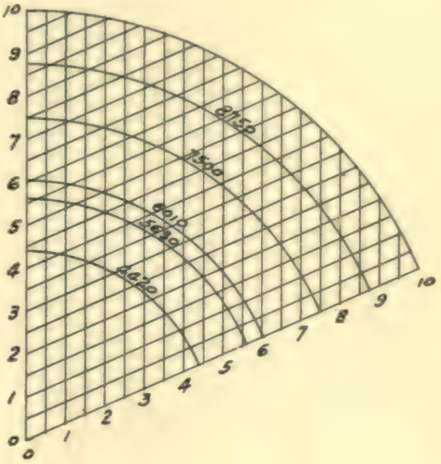
20 Rivets per row.
C=870.40

PLATE 24

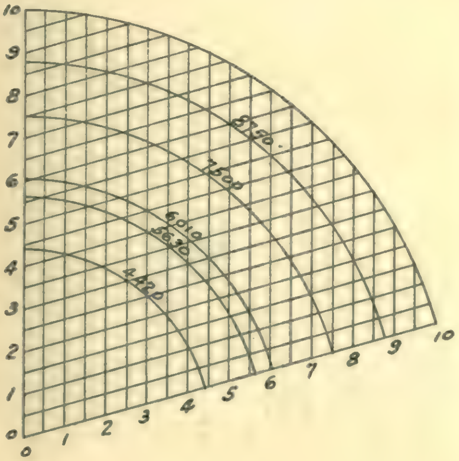
Two rows of rivets - $2\frac{1}{8}$" ctr. to ctr. of rows.
Rivets staggered - alternate spaces $1\frac{1}{2}$" ctr. to ctr.



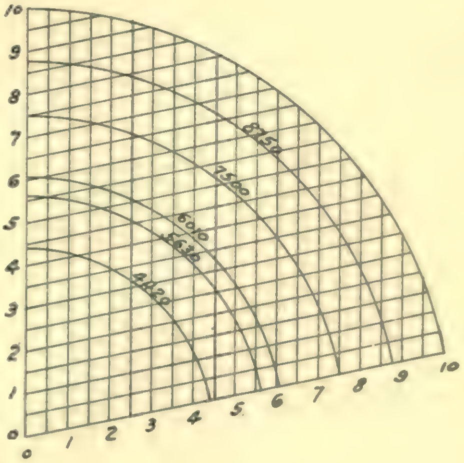
C for 2 rivets = 2.60



C for 3 rivets = 4.50
C " 4 " = 6.30



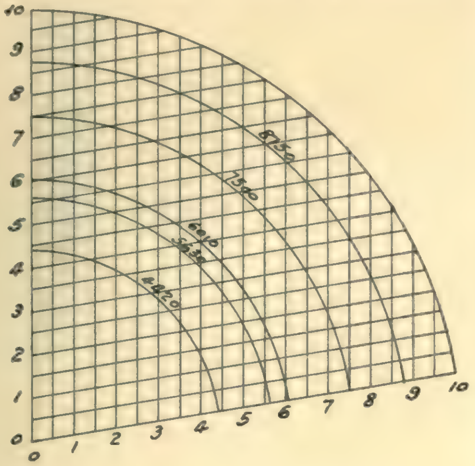
C for 5 rivets = 8.90
C " 6 " = 11.80



C for 7 rivets = 15.40
C " 8 " = 19.30

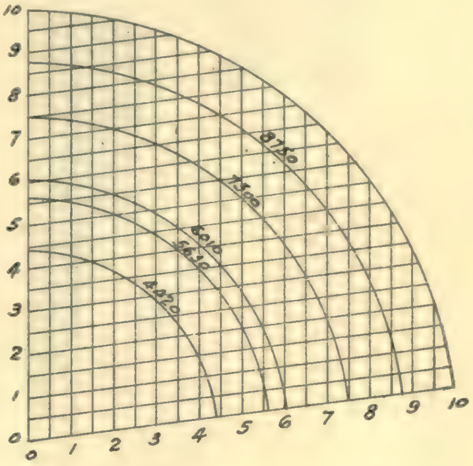
Two rows of rivets - $2\frac{1}{8}''$ ctr. to ctr. of rows.

Rivets staggered - alternate spaces $1\frac{1}{2}''$ ctr. to ctr.



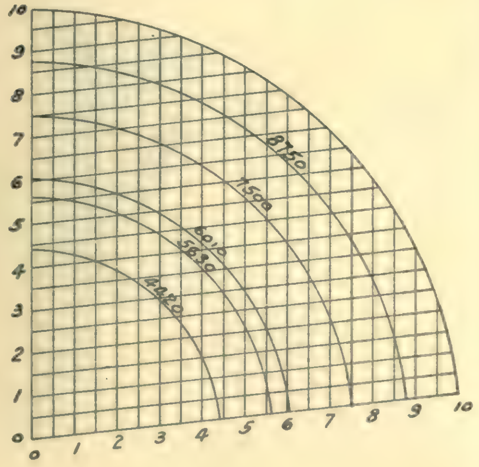
C for 9 rivets = 23.90

C " 10 " = 28.80



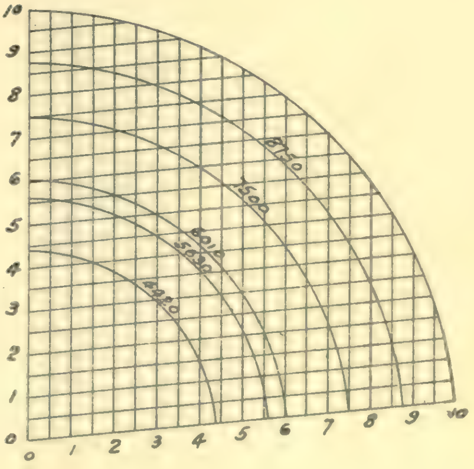
C for 11 rivets = 34.40

C " 12 " = 40.30



C for 13 rivets = 46.90

C " 14 " = 53.80

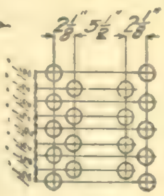


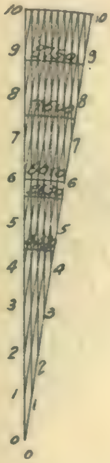
C for 15 rivets = 61.30

C " 16 " = 69.30

Four rows of rivets-distances between rows $2\frac{1}{8}"-5\frac{1}{2}"-2\frac{1}{8}"$ ——→

Rivets staggered-alternate spaces $1\frac{1}{2}"$ ctr. to ctr.


$2\frac{1}{8}"$
$5\frac{1}{2}"$
$2\frac{1}{8}"$

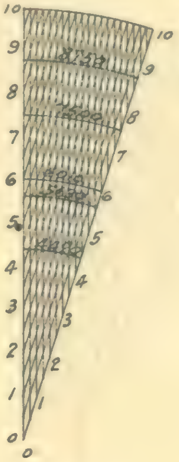

0
1
2
3
4
5
6
7
8
9
10
8750
7500
6010
5630
4420

1 Space

1 rivet per row

4 = total no. of rivets.

C = 13.10


0
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8750
7500
6010
5630
4420

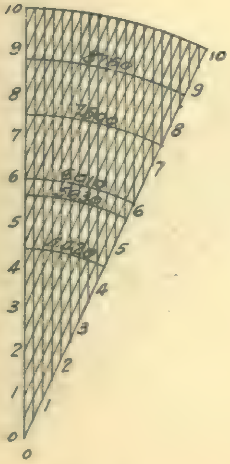
2 Spaces

6 = total no. of rivets

2 rivets in each outside row.

1 rivet " " inside "

C = 23.30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8750
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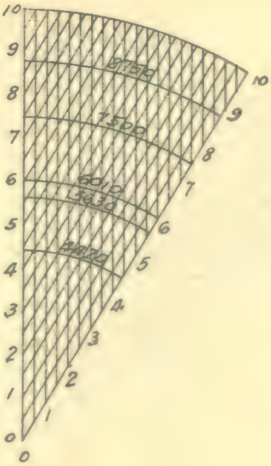
3 Spaces

8 = total no. of rivets

2 rivets per row

C = 27.60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8750
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4 Spaces

10 = total no of rivets

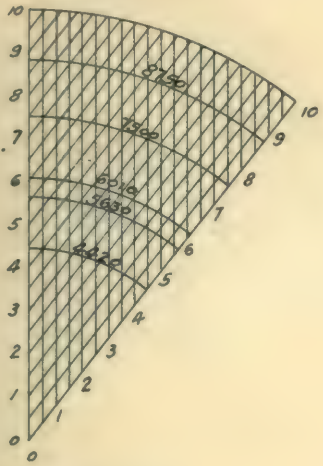
3 rivets in each outside row

2 " " " inside "

C = 37.80

PLATE 27

Four rows of rivets- distances between rows 2⅛"-5½"-2⅛"-See page 26
Rivets staggered- alternate spaces 1½" ctr. to ctr.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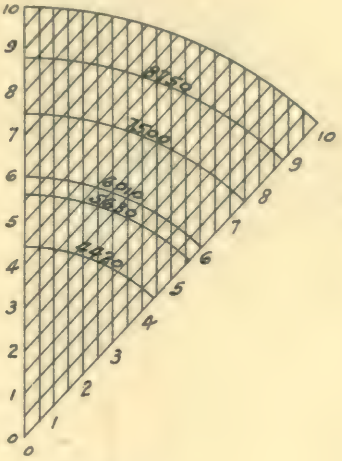
5 Spaces
12 = total no. of rivets
3 rivets per row
C = 43.40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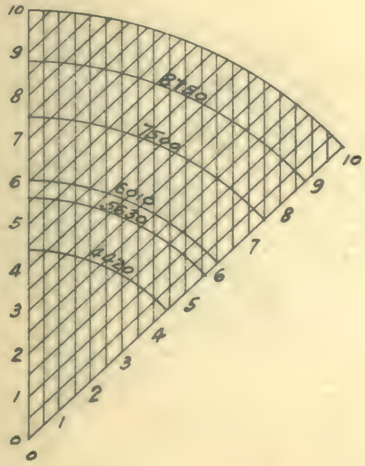
6010
5630
4420

6 spaces.
14 = total no. of rivets.
4 rivets in each outside row
3 " " " inside "
C = 54.60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8750
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6010
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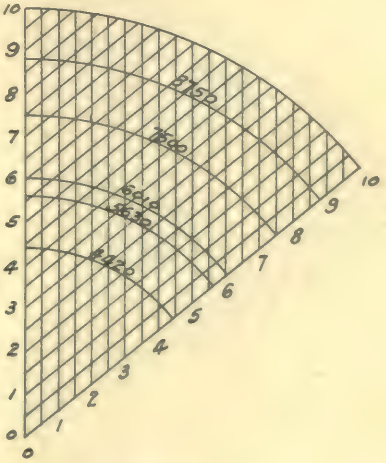
4420

7 spaces.
16 = total no. of rivets.
4 rivets per row.
C = 61.40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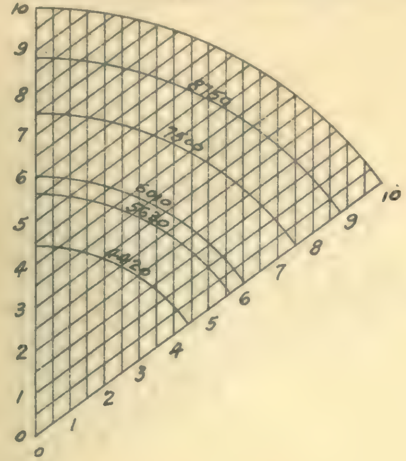
8 spaces.
18 = total no. of rivets.
5 rivets in each outside row
4 " " " inside "
C = 73.80

Four rows of rivets - distances between rows $2\frac{1}{8}''$-$5\frac{1}{2}''$-$2\frac{1}{8}''$ - see page 26
Rivets staggered - alternate spaces $1\frac{1}{2}''$ ctr. to ctr.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8750
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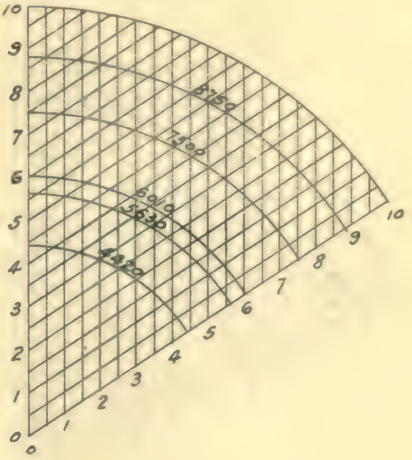
6010
5830
4420

9 spaces
20 = total no. of rivets
5 rivets per row.
C = 82.30.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8750
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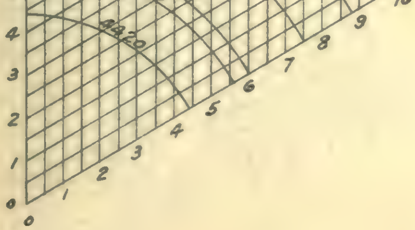
5830
4420

10 spaces
22 = total no. of rivets
6 rivets in each outside row
5 " " " inside "
C = 95.70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8750
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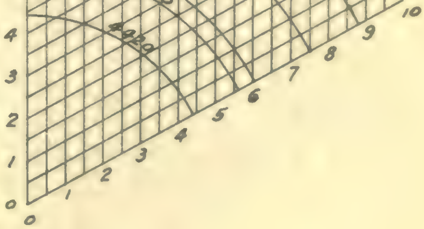
6010
5830
4420

11 spaces
24 = total no. of rivets
6 rivets per row.
C = 106.20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8750
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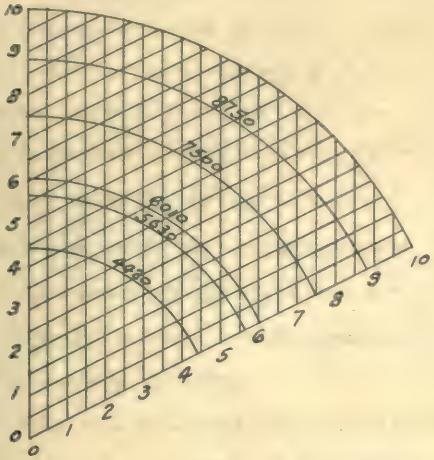
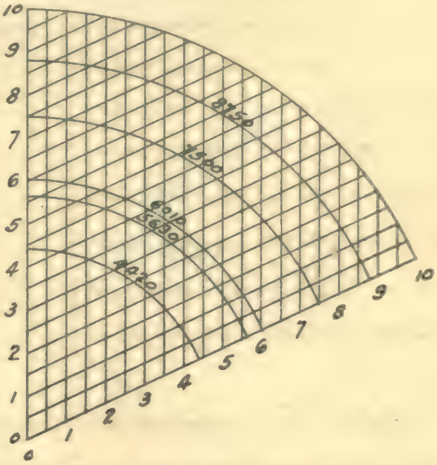
6010
5830
4420

12 spaces
26 = total no. of rivets.
7 rivets in each outside row.
6 " " " inside "
C = 121.30.

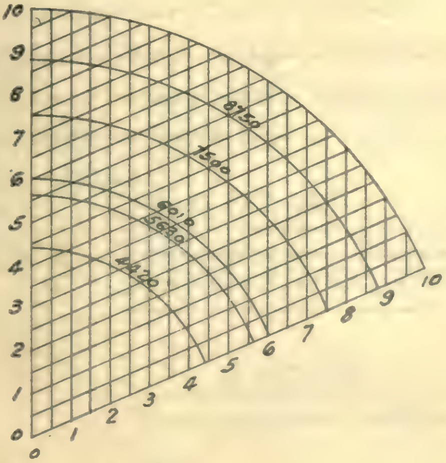
Four rows of rivets-distances between rows $2\frac{1}{8}''$-$5\frac{1}{2}''$-$2\frac{1}{8}''$.-see page 26
Rivets staggered-alternate spaces $1\frac{1}{2}''$ ctr. to ctr.



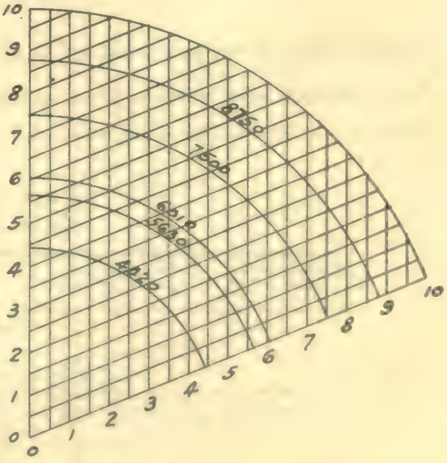
13 spaces
28 = total no. of rivets.
7 rivets per row.
C = 134.40



14 spaces
30 = total no. of rivets.
8 rivets in each outside row.
7 " " " inside "
C = 150.90



15 spaces
32 = total no. of rivets.
8 rivets per row
C = 165.70



16 spaces
34 = total no. of rivets.
9 rivets in each outside row.
8 " " " inside ".
C = 183

The following substitutions can be made without any appreciable error:

For two rows of rivets $2\frac{1}{4}''$ c. to c. of rows, rivets spaced alternately $1\frac{1}{2}''$ c. to c.	use values for	two rows of rivets $2\frac{1}{8}''$ c. to c. of rows - pages 24-25.
For two rows $> 5\frac{1}{4}''$ and $< 6''+$ c. to c. - rivets spaced 3" c. to c. - not staggered	"	two rows $5\frac{1}{4}''$ c. to c. of rows - pages 9 to 13 inclusive.
For four rows $2\frac{1}{4}''$-$5\frac{3}{8}''$-$2\frac{1}{4}''$ c. to c. - rivets spaced 3" c. to c. - not staggered	"	four rows $2\frac{1}{4}''$-$5\frac{1}{4}''$-$2\frac{1}{4}''$ c. to c. of rows - pages 19 to 23 inclusive.
For four rows $2\frac{1}{4}''$-$5\frac{1}{4}''$-$2\frac{1}{4}''$ c. to c. or $2\frac{1}{4}''$-$5\frac{3}{8}''$-$2\frac{1}{4}''$ c. to c. - rivets spaced alternately $1\frac{1}{2}''$ c. to c.	"	four rows $2\frac{1}{8}''$-$5\frac{1}{2}''$-$2\frac{1}{8}''$ c. to c. of rows - pages 26 to 29 inclusive

The coefficients, or values of C, represent the values of $\frac{\Sigma d^2}{y_1}$ where $d_1^2 + d_2^2 + d_3^2 + \cdots + d_{n-1}^2 + d_n^2$ is the sum of the squares of the distances of the rivets from the center of gravity of all the rivets $= \Sigma d^2$, and where y_1 = the distance of the extreme rivet from the center of gravity of all the rivets.

The value of C for a single row of rivets with a given uniform pitch, x, is to the value of C for another row of the same number of rivets, but with a pitch $= x+a$, as $x : \overline{x+a}$ as may be shown thus:

Let C = the value of $\frac{\Sigma d^2}{y_1}$ for the row with the pitch x.

" C' = " " " " " " " " " " $x+a$.

To show that $C : C' :: x : \overline{x+a}$

Suppose the number of rivets in each row to be odd, and then there will be n rivets and n equal spaces above and below the center of gravity of each row of rivets where the number of rivets in each row $= 2n+1$.

$$\text{Then } \frac{C}{C'} = \frac{\dfrac{2\left\{x^2 + \overline{2x}^2 + \overline{3x}^2 + \cdots + \overline{(n-1)x}^2 + \overline{nx}^2\right\}}{nx}}{\dfrac{2\left\{\overline{x+a}^2 + \overline{2(x+a)}^2 + \overline{3(x+a)}^2 + \cdots + \overline{(n-1)(x+a)}^2 + \overline{n(x+a)}^2\right\}}{n(x+a)}}$$

$$= \frac{x + 2x + 3x + \cdots + (n-1)x + nx}{(x+a) + 2(x+a) + 3(x+a) + \cdots + (n-1)(x+a) + n(x+a)}$$

$$= \frac{\frac{n}{2}\left\{2x + (n-1)x\right\}}{\frac{n}{2}\left\{2(x+a) + (n-1)(x+a)\right\}} = \frac{(n+1)x}{(n+1)(x+a)} = \frac{x}{x+a} \quad \text{Q.E.D.}$$

Similarly the same result may be obtained for an even number of rivets.

In the diagrams the ordinates represent the vertical shear and are therefore drawn vertically. The abscissae represent the shear on the extreme rivet due to bending, and since this shear acts perpendicularly to the straight line joining the extreme rivet with the center of gravity of all the rivets they are drawn perpendicularly to that line. The distance from the origin of coördinates to the intersection of any ordinate and abscissa represents the resultant shear.

Technol.

Author Rexford, E. A.

Title Tables and diagrams for obtaining the resisting moments of eccentric riveted connections.

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